Paradigms of governing the transition to a sustainable energy system and their implications for technology development

Hisschemoller, M.; Bode, M.G.A.

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Paradigms of governing the transition to a sustainable energy system and their implications for technology development

A critical reflection

Matthijs Hisschemöller and Ries Bode

With contributions from Harm Jeeninga (ECN Policy Studies)

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Internally reviewed by: Dr. Marleen van de Kerkhof.

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IVM

Institute for Environmental Studies
Vrije Universiteit
De Boelelaan 1087
1081 HV Amsterdam
The Netherlands

Tel. ++31-20-5989 555
Fax. ++31-20-5989 553
E-mail: info@ivm.falw.vu.nl

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Nederlandse samenvatting[1]

Sturingsparadigma's voor de transitie naar een duurzaam energiesysteem en hun implicaties voor technologieontwikkeling, een kritische reflectie.

Het probleem

Er is te weinig geïntegreerde kennis voorhanden op het gebied van de politiek institutionele kanten van de transitie naar een duurzaam energiesysteem. Technologen, economen en politieke wetenschappers wisselen hun inzichten op dit gebied nauwelijks uit. Hoewel er onder stakeholders een groeiende behoefte aan dergelijke inzichten en onderzoek wordt geuit, lijken Nederlandse beleidsmakers een onderzoek naar de wisselwerking
tussen technologieën en instituties minder relevant te achten. In het transitievertoog staat immers niet het stimuleren van specifieke technologieën centraal maar het idee dat generiek beleid nodig is om marktwerking te prikkelen en te reguleren. De overheid kan de vorming van winnende coalities van marktpartijen stimuleren.

Desalniettemin maakt het beleid in de praktijk toch vele keuzen die specifieke technologieën bevoordelen ten koste van andere. Dit komt vooral naar voren in de afbakening van beleidsproblemen en in de keuze voor bepaalde beleidsinstrumenten: waarom wel een Europees beleid om biobrandstoffen voor de transportsector te stimuleren en niet emissievrije of beperkende transportbrandstoffen in het algemeen? Waarom kiest de EU voor voortschrijdende normstelling en kiezen bepaalde lidstaten voor fiscale maatregelen om het marktaandeel van biobrandstoffen te bevorderen? Waarom wordt in Nederland vraagbeperking voor gebouwen via voortschrijdende normstelling gestimuleerd (met name isolatie) en ontbreekt een samenhangend beleid gericht op investeringen in vraag en aanbod–technologieën? Het lijkt onwaarschijnlijk dat op deze en tal van andere
vragen een eenduidig antwoord mogelijk is. Het maken van keuzes is onvermijdelijk.

In zekere zin is het problematiseren van de wisselwerking tussen de politiek institutionele en de technologische aspecten dan ook het openen van een doos van Pandora
waardoor een breed scala aan discussies en belangentegenstellingen kan worden opgeroepen. Vanuit de beleidsoptiek is het wellicht aantrekkelijker om deze discussie uit de weg te gaan en het te doen voorkomen alsof het managen van de transitie niet een inhoudelijk maar een regieprobleem is, waarbij een slimme vorm van 'netwerksturing' toereikend is om de complexe problemen op te lossen.

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[1] Deze explorerende studie werd uitgevoerd in het kader van het NWO/NOVEM Stimuleringsprogramma Energie Onderzoek en in het kader van het project Governing the Transition to a Sustainable Hydrogen Economy dat wordt uitgevoerd in het kader van het NWO/ACTS
programma Sustainable Hydrogen. De auteurs zijn dank verschuldigd aan leden van de commissie Energie onderzoek voor hun commentaar op een eerdere versie van dit rapport. Alle verantwoordelijkheid voor de inhoud ligt bij de auteurs.

Er zijn tenminste twee redenen om het politieke karakter van de energietransitie wel te problematiseren: ten eerste neemt voor Nederland alsook voor andere geïndustrialiseerde landen de urgentie van de overgang naar een duurzaam energiesysteem toe. Een beleid dat niet gericht is op het verwezenlijken van lange termijn doorbraken kan op den duur wel eens een kostbaar beleid blijken te zijn. Immers, de markt stimuleert partijen om steeds de goedkoopste oplossingen voor de korte termijn te zoeken. Ten tweede: er zijn, zowel in historische als in theoretische zin, alternatieven voor de sturing van de energietransitie voorhanden. Zowel vanuit het oogpunt van politieke rationaliteit als vanuit academische nieuwsgierigheid is het de moeite waard deze te exploreren.

Aanpak van de studie

In deze explorerende studie wordt nagegaan welke bijdrage politieke theorieën, d.w.z. theorieën waarin de relatie tussen overheid en burgers centraal staat, kan leveren aan het sluimerende maatschappelijke debat over de energietransitie. Er wordt in deze studie uitdrukkelijk niet gekeken naar de doorgaans bestudeerde aspecten als kosten en maatschappelijk draagvlak.

Specifieke doelstellingen zijn:

1. Een aantal institutionele factoren te identificeren die cruciaal zijn voor het succes van technologische opties. Dit gebeurt ‘bottum-up’, namelijk door een verkenning van enkele als kansrijk beschouwde duurzame energie opties;
2. Het beschrijven van vier zogenaamde sturingsparadigma’s die worden afgeleid van politieke theorieën. Hierbij gaat het dus niet om onderzoek naar opvattingen in de praktijk maar om het verhelderen en rechtvaardigen van verschillende normatief theoretische posities die elk op zichzelf consistent zijn;
3. Te bezien hoe de sturingsparadigma’s de ‘kansrijkheid’ van verschillende technologische opties kunnen bepalen;
4. Het identificeren van relevante thema’s voor toekomstig beleid en onderzoek.

Institutionele kenmerken van energietechnologieën

De volgende opties worden verkend:

Aan de aanbodzijde:

1. All electric: elektriciteit wordt grootschalig geproduceerd uit aardgas in combinatie met CO2 opslag aangevuld met kleinschalig geproduceerde stroom uit duurzame bronnen. Laagwaardige warmte. In deze optie is geen ruimte voor een aardgas-infrastructuur;
2. Centrale waterstof infrastructuur (als opvolger van de aardgas infrastructuur) in combinatie met decentrale micro warmtekracht. In deze optie is geen ruimte voor een elektriciteit infrastructuur;
3. Grootschalige inzet van synthetisch gas (syngas) uit biomassa met gebruikmaking van de bestaande aardgas infrastructuur.

Aan de vraagzijde:

4. Demand management: investeringen in vraagbeperking concurreren in de praktijk met aanbodtechnologie. Door de individuele keuze mogelijkheden is dit een lastig stuurbare optie.

Voor de transportsector:

5. Waterstof al dan niet in combinatie met de brandstofcel. Levering geschiedt via de pomp of eventueel via 'home fuelling'.

Elk van de beschreven opties kan gekoppeld worden aan een reeks van institutionele dimensies, waarvan het meest in het oog springen:

- Is er een strategisch (collectief / nationaal) belang in het geding? Deze dimensie wordt toegespitst op het vraagstuk van de *voorzieningszekerheid*;
- Is *infrastructuur* een *collectief* dan wel een *privaat* goed?
- Vindt de productie en levering *centraal* dan wel *decentraal* plaats?
- In hoeverre heeft de consument *keuzevrijheid*?
- Is er sprake van afwenteling van *externe kosten*?

In de volgende tabel is samengevat hoe, gegeven in het rapport behandelde veronderstellingen, de implementatie van de energie opties door institutionele variabelen kunnen worden bevorderd dan wel belemmerd.

Vijf energieopties en hun mogelijke institutionele implicaties.

	All Electric	Centrale H2	Syngas	Vraag	Transport
Voorzieningszekerheid	Ja Meer bronnen	Nee 1 bron	Nee 1 bron	Ja	Ja
Collectief-Privaat*	Ja	Ja	Ja	Nee	Nee
Centraal-decentraal*	Beide	Ja	Ja	Nee	Ja
Keuzevrijheid	Ja	Nee	Nee	Ja	Ja
Afwenteling	Ja, bij toename decentraal	Nee	Ja, bij groot-schalige import	Nee	Nee

* Verwijst naar het eerste element van dichotomie.

De exercitie leidt tot een aantal observaties die haaks staan op het in Nederland dominante transitievertoog.

Ten eerste blijkt het allesoverheersende belang van de factor infrastructuur. Opties die kunnen profiteren van bestaande infrastructuur (centraal all-electric, syngas of waterstof voor de transportsector) hebben betere kansen dan opties waarvoor een infrastructuur ontwikkeld moet worden. Zowel vanwege de kosten als anderszins veronderstellen keuzes ten aanzien van infrastructuur vermoedelijk ook in de toekomst een hoge mate van overheidsbemoeienis vanwege het collectieve goed karakter van infrastructuur voorzieningen. De conclusie dringt zich op dat, naarmate een optie hogere infrastructurele investeringen vergt, meer *specifiek* overheidsbeleid noodzakelijk is, terwijl bij lage kosten van de infrastructuur een generiek beleid kan volstaan (syngas).

Ten tweede lijken opties die realiseerbaar zijn binnen het kader van de gevestigde belangen in de energie sector (infrastructuur) een streepje voor te hebben op opties die zich (vooralsnog) ontwikkelen in de marge van de gevestigde netwerken. Dit heeft er ook mee te maken dat centrale productie en levering gemakkelijker te sturen zijn dan decentrale opties (kleinschalige all-electric of woningisolatie).

Ten derde zijn opties die kunnen profiteren van bestaande infrastructuur niet vanzelfsprekend de beste uit het oogpunt van voorzieningszekerheid of keuzevrijheid consument. Dit geldt voor centrale H2, syngas en een op aardgas of syngas leunende centrale all-electric variant.

Ten vierde, en in tegenspraak met het vorige punt, een substantiële toename in decentrale all-electric in combinatie met demand management en eventueel 'home fuelling' lijkt hoger te scoren op voorzieningszekerheid maar lijkt ondermijnend voor de gevestigde belangen in de energiesector. Bovendien heeft deze optie een potentieel afwentelings-effect, want consumenten zullen niet snel bereid zijn mee te betalen aan de infrastructuur die nodig is om overschotten op te vangen. Deze optie laat zich vanzelfsprekend ook lastig sturen, maar het belang van een goede infrastructuur is niet minder groot dan bij een centrale voorziening.

Hoewel deze observaties het karakter hebben van tentatieve hypothesen, gebaseerd op wellicht discutabele veronderstellingen, leiden zij wel tot een zeer relevante conclusie: institutionele factoren en de bijbehorende politieke keuzes hebben, naast technologische en economische factoren die hier niet worden behandeld, een verregaande impact op de ontwikkelingskansen van duurzame energieopties. Het beeld van de overheid als regisseur die via generieke maatregelen innovaties stimuleert, miskent de politieke dimensie van het energiebeleid.

Sturingsparadigma's

De onderscheiden institutionele factoren hebben alle een meer of minder geprononceerde plaats in sturingsparadigma's voor de overgang naar een duurzame energievoorziening die zijn ontleend aan de politieke theorie.

Staatssturing (Governance by Government)

Dit paradigma steunt op twee cruciale veronderstellingen over de rol van de (nationale) staat: ten eerste dient de overheid het algemeen belang (collectieve goederen waaronder een efficiënte energievoorziening en een schoon milieu) te garanderen. Hiertoe zijn, binnen de grenzen van de wet, alle middelen en instrumenten geoorloofd. Ten tweede: bestuurders laten zich in hun beleidskeuzen leiden door 'objectieve' wetenschappelijke kennis. 'Social engineering' is een sleutelbegrip binnen deze sturingsconceptie. Kenmerkend zijn het nagenoeg ontbreken van mogelijkheden tot open participatie en debat. Door de dominante aanwezigheid van de overheid, die technologische innovaties stuurt, wordt concurrentie tussen ondernemingen aan banden gelegd. Een veel aangehaald
historisch voorbeeld van dit paradigma als beleidsstrategie in de praktijk betreft de Amerikaanse ruimtevaart- en bewapeningsprogramma's in de jaren 1945 – 1965. Volgens velen is deze strategie niet langer haalbaar. Een belangrijke reden is dat wetenschap en technologie steeds meer omstreden zijn geworden (kernenergie). Tegelijkertijd heeft participatie aan belang gewonnen en daarmee symbolisch beleid, gericht op beeldvorming en draagvlak. In samenhang hiermee is social engineering in diskrediet geraakt vanwege gevallen van belangenverstrengeling en ontoelaatbare staatssteun aan afzonderlijke bedrijven, in Nederland gesymboliseerd door de RSV affaire in de jaren 1980. Maar wie weet komt er een nieuwe kans voor dit paradigma

wanneer strategische belangen
zoals voorzieningszekerheid als gevolg van internationale ontwikkelingen en de moordende concurrentie tussen energieleveranciers onder druk komt te staan?

Netwerksturing (Governance by Policy Networking)

Dit paradigma vormt het hedendaagse alternatief voor het als verouderd beschouwde staatssturingsmodel. Er wordt gewezen op een overgang van Government naar Governance en de toenemende onderlinge afhankelijkheid van verschillende bestuurslagen (multi-level governance). Stakeholderparticipatie wordt beschouwd als een belangrijk middel voor consensusvorming, waarbij praktijkkennis van stakeholders positief wordt gewaardeerd. In de beleidswetenschappelijke theorie maken begrippen als 'belangen' en 'macht' plaats voor begrippen als 'discourse' en 'beleidsgericht leren'. Dit sturingsparadigma legitimeert enerzijds het moderne polderdenken, maar steunt op politieke theorieën over consensusdemocratie die dateren uit de periode van de verzuiling. Er wordt verschillend gedacht over de mogelijkheden van netwerksturing voor het stimuleren van innovaties. Als voordelen van een dergelijke sturingsstrategie worden
genoemd de stakeholderparticipatie en het gebruik van een diversiteit aan kennis, het delen van kennis en de pragmatische benadering die win-win uitkomsten vergemakkelijkt. Consensusdemocratieën zouden hoger scoren op energie-efficiency dan zogenaamde meerderheidsdemocratieën. Als nadelen worden genoemd het hoge gehalte aan
symbolisch beleid en het risico dat netwerk consensus gaat leiden tot het rondzingen van als vaststaand aangenomen denkbeelden waardoor kritische en innovatieve ideeën buiten de boot vallen. Een voorbeeld zou kunnen zijn dat in Nederland het Ministerie van EZ en een aantal stakeholders met elkaar hebben afgesproken dat zon de komende 50 jaar niet tot de voor Nederland kansrijke energieopties behoort, waardoor doorbraakinitiatieven die gebruik maken van zon de kans lopen genegeerd te worden.

Sturing door het internationale bedrijfsleven (Governance by Corporate Business)

De econoom en politicoloog Schumpeter wees er op dat technologische vernieuwing de drijvende kracht is achter het succes van de kapitalistische productiewijze. Het implementeren van vernieuwingen wordt in de hand gewerkt door de concurrentiedruk. In het streven de concurrentie voor te blijven wordt kapitaalvernietiging voor lief genomen (creatieve destructie). Het zijn de grote internationaal opererende bedrijven, zoals de oliemaatschappijen, die in de energietransitie een trekkersrol vervullen. Zij kunnen als geen ander inspelen op internationale ontwikkelingen. Bovendien hebben zij een primair belang bij het inspelen op de preferenties en waarden van hun afnemers. In dit paradigma participeren consumenten dan ook met name via het marktmechanisme. Overheden
kunnen een (bescheiden) bijdrage aan dit proces leveren maar mogen het niet verstoren. Dit betekent dat zij milieuregels mogen stellen en ook financieel kunnen bijspringen, mits de concurrentie hiermee geen geweld wordt aangedaan. Concurrentieondermijnend zijn bijvoorbeeld het verplicht stellen van bepaalde specifieke opties (biobrandstoffen via belastingvrijstelling) maar een beleid dat binnen een lange termijn (pakweg 20 jaar) een overgang naar klimaatneutrale transportbrandstoffen regelt kan de concurrentie

bevorderen. Gegeven de veronderstelde voordelen voor de consument (gemak, comfort en milieuvoordelen) zou de geleidelijke overgang naar brandstofcellen in het vervoer wellicht via dit sturingsparadigma te realiseren zijn.

Sturing door uitdaging (Governance by Challenge)

Een breed scala aan politieke en sociologische theorieën relateert ingrijpende veranderingen in beleid of technologie aan wijzigingen in de samenstelling van dominante
netwerken van actoren. In samenhang hiermee wordt wel gewezen op diepgaande veranderingen in de sociaal-economische verhoudingen (productie en distributie van goederen en diensten) alsmede de common sense veronderstellingen achter het beleid. Het omverwerpen van vigerende beleidsparadigma's is wel vergeleken met de door Kuhn beschreven dynamiek van wetenschappelijke innovaties.

Door de monopolievorming in het bedrijfsleven en de toenemende invloed van de overheid in het maatschappelijk leven zijn tal van regels, bureaucratieën en intermediaire organisaties ontstaan die gevestigde belangen een geprivilegieerde positie geven ten opzichte van 'nieuwkomers'. De belangrijkste taak van een innovatiebeleid bestaat er uit de gevestigde belangen, waaronder tal van door de overheid zelf gestelde regels, aan te pakken, waar deze de concurrentie met innovaties de pas afsnijden. De grootste moeilijkheid hierbij is misschien niet zozeer de te verwachten tegenwerking door gevestigde machten, maar het feit dat nieuwe mogelijkheden over het hoofd worden gezien. Elke status quo beperkt namelijk het waarnemingsvermogen van actoren en draagt bij aan een zekere mate van 'cognitieve blindheid' (*cognitive impairment*, volgens Lindblom). De uitdaging voor de politiek is het ondermijnen van bestaande netwerken door het verkennen van opvattingen die niet of slechts marginaal binnen deze netwerken vertegenwoordigd zijn. Vanuit dit paradigma geredeneerd zijn afspraken tussen departementen en stakeholders over voor Nederland kansrijke energieopties uit den boze, want zij ondermijnen de kansen voor innovatie. Een tweede uitdaging voor het beleid is, zoals al bepleit door J.S. Mill, het versterken van de keuzevrijheid van de consument en de mogelijkheden voor consumenten om controle uit te oefenen op het beleid van energieleveranciers, zeker wanneer het (semi)monopolies of overheidsbedrijven betreft.

Slotbeschouwing

De vier beschreven sturingsparadigma's verhouden zich elk op een eigen wijze tot de behandelde energie opties met hun specifieke institutionele kenmerken. Uitgaande van de Nederlandse situatie, die gekenmerkt wordt door een zwaar accent op aardgas en een sterke internationalisering van de elektriciteitssector, worden enkele tentatieve veronderstellingen geformuleerd:

- De thans meest populaire paradigma's met een relatief terughoudende overheid (Netwerksturing en Sturing door het Internationale Bedrijfsleven) leiden opmerkelijk genoeg tot een situatie waarin de nationale aardgasbelangen vermoedelijk niet opkunnen tegen de internationale elektriciteitssector. Een traject richting centrale H2 infrastructuur, waarbij het elektriciteitsnet overbodig wordt, kan vermoedelijk niet zonder overheidssteun worden doorgezet. In het geval deze schoon fossiel optie wordt ondersteund met een krachtig CO2 beperkend beleid, dan zal dit beleid door

de internationale elektriciteitssector politiek en wellicht ook juridisch kunnen worden aangevochten. Een compromis rond syngas lijkt vanuit deze sturingsparadigma's het meest voor de hand liggend. Een centrale H2 infrastructuur veronderstelt de terugkeer naar het paradigma Staatssturing, maar dit is vermoedelijk alleen mogelijk wanneer de voorzieningszekerheid of de leveringszekerheid van elektriciteit daadwerkelijk wordt bedreigd;

- Het paradigma Sturing door Uitdaging zal vermoedelijk ruimte bieden aan een traject waarin centrale en decentrale opties worden gecombineerd. Hierbij is enerzijds aandacht voor de keuzevrijheid van de consument en anderzijds voor het waarborgen van een adequate infrastructuur;
- Klimaatneutrale transportbrandstoffen lijken kansrijk in elk sturingsparadigma. De brandstofcel optie voor de mobiele sector lijkt op termijn kansrijk vanuit het paradigma Sturing door het Internationale Bedrijfsleven. Er is immers nu al een trend binnen de oliemaatschappijen gaande waarin het zwaartepunt van olie wordt verlegd naar gas.

Maar los van deze inhoudelijke hypothesen is de vraag gerechtvaardigd in hoeverre het Nederlandse energiebeleid gebaat is bij een meer fundamenteel debat over de vraag naar politieke sturing. Met name bij stakeholders uit het bedrijfsleven leeft de opvatting dat het overheidsbeleid in Nederland op verschillende gedachten hinkt en dat een energietransitiebeleid met de overheid in een regierol, zonder de politiek heikele koeien bij de horens te vatten, voor de langere termijn geen soelaas biedt. De theoretische exercitie in deze verkenning ondersteunt de opvatting dat er alternatieven bestaan die in de nabije toekomst misschien aantrekkelijker zijn. Onder de huidige omstandigheden lijkt een
situatie te zijn ontstaan waarin overheid en bedrijfsleven op elkaar wachten. Met name een reflectie en nadere uitwerking van het Uitdagingsparadigma kan misschien een impuls opleveren voor politieke interventies die ondersteuning bieden bij initiatieven van onderop zonder te vervallen in een benadering waarbij de overheid bepaalt hoe de energievoorziening er in Nederland uit moet zien.

1. The anti-political bias in transition discourse

There is a lack of integrated knowledge on the transition to a sustainable energy system. Technologists, economists and political scientists hardly interact with respect to their disciplinary insights on the institutional aspects of the issue. Although we observe a growing interest among stakeholders into further exploring the relationship between technologies and institutions[2], Dutch policy makers tend to be captured by beliefs that render a critical investigation into this relationship less relevant.

There is a widespread belief in 'generic' policies. Policies should not be immediately aimed at stimulating specific technologies but they should regulate the market. On the one hand, economic instruments, especially the establishment of an emissions trading regime, is considered particularly fit to facilitate the adoption of low emission energy technologies. On the other hand, there is a broadly shared belief in process management. Being unable to immediately shape the courses of technological innovation in an era of liberalization, government is supposed to focus on network management in order to create a shared willingness among economic actors for realizing the energy transition. In both perspectives the technologies themselves do not really matter. According to transition discourse, government should not see it as its main task to take sides in the competition between energy technologies or energy carriers. This is perfectly illustrated by a recent Dutch policy document, which states that once a tradable emission system has been established, "the right conditions emerge that make the market do the work. In conformity with the market, a new selection mechanism for innovations will come up. Under these conditions, there is no need for government to make choices – the winners will themselves come forward." According to this document, energy policy so far has failed to trigger "creativity, entrepreneurship and innovation. What apparently lacks is a 'sense of opportunity', if policies are too much focused on specific technologies, as has been the case until recently." (Department of Economic Affairs, 2004: 13. authors' translation).

Obviously, rhetoric and reality are separate things. Neither regulation through emission trading schemes nor a sophisticated process architecture would suffice to define the actual or future role of government (Dutch or any other) in energy policy. Apart from the lasting need for (inter)national investments in research & development, government interventions may focus on investments and regulations with respect to infrastructure requirements, safety and environmental concerns, as well as on taking early mover initiatives. Governments are intervening in many different ways, thereby shaping the adoption of *specific* innovations, possibly at the expense of others. As regards the housing and construction sector, progressive standard setting has proved to be a powerful instrument to increase the efficiency of domestic appliances and is expected to remain very useful in the decades to come. The same is true for the case of improving the efficiency of buildings by energy efficiency standards. The EU biofuels directive is

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[2] See the conclusions and recommendations from the national stakeholder dialogue in the COOL-project (Climate OptiOns for the Long term), in Hisschemöller (2001) and Hisschemöller and others, 2001). See also the recent report by Hisschemöller and Van de Kerkhof (2004) on the dialogue preceding the *Themadag Klimaatverandering*.

aimed at increasing the share of biofuels for the transportation sector through the setting of progressively revised targets. A number of EU member states have already implemented fiscal measures to make biofuels competitive with mainstream fossil transport fuels. In several countries, financial instruments are used to promote the adoption of small scale solar PV and wind. And although the Netherlands cannot be considered a forerunner as compared to countries like Germany, Denmark or France, even here large scale innovations seem unthinkable without specific government interventions in favor of certain technological trajectories.

Interventions that affect the market potential of specific technologies are vulnerable for critique as they articulate choices that are often hidden and not publicly debated. Even interventions that are presented as being of a more generic nature, are not free from technological bias. Legitimate questions do arise, such as: Why focus on targets for the adoption of biofuels instead of low emission transport fuels in general, including biofuels, natural gas and hydrogen? Why focus on further strengthening construction standards for new buildings instead of developing policies and standards that allow for combining demand and supply options for the new as well as for the existing dwellings supply? How do we know that a European emissions trading regime will positively affect the speed of innovations? It would make equal sense to hypothesize that such an institutional device will provide a strong incentive to implement the cheapest possible options for the short term and a disincentive to start making investments for long term innovations. To what extent are subsidies to foster the share of renewables in the electricity supply an adequate instrument to trigger a development directed at competitiveness of solar? Why not start from the hypothesis that protective subsidies will provoke a climate of slag in this innovation area?

These and other questions have in common that they may lead to contradictory hypotheses, which may point into different policy directions: As yet, we don't have answers to all questions available. We even don't know what the right questions are. In some cases, generic policies may be preferable, in other it may be wise to heavily support a specific innovation trajectory for a longer period of time. But whatever choices are being made, they are always likely to have an impact on the possibilities and the directions of technological change. This report will not convey the message that there is anything wrong with making choices. Choices are unavoidable.

Why then is it that energy transition discourse seems not really interested in exploring the relationship between the technological and the political? One likely answer to this question is the nature of the problem. If one could reasonably expect that investigating how institutional arrangements affect technology and vice versa, might lead to a multitude of contradictory questions, hypotheses and political alternatives, some of these pointing in the direction of specific technology support and others to more generic interventions, what would justify to open Pandora's box? Why starting a seemingly endless debate on the interests related to specific sectors and technological regimes if the alternative would be to 'manage' the transition in a much smoother way, that is without any such debate at all? Would it not be the highest achievement of politics to organize itself into the margin of the energy transition, thereby leaving technological choices to coalitions of transition actors and, in last instance, to the market?

There are two good reasons for at least exploring some of the alternatives for what we consider the anti-political bias in energy transition discourse. The first relates to the sense of urgency with respect to the socio-economic and environmental problems that must be tackled. If climate changes will evolve as many scientists expect, the global community may face increasing conflicts of liability and burden sharing among nations, regions and economic sectors. The sense of urgency may go up, leading to more stringent international commitments and policies. For countries such as the Netherlands, the costs for substantially reducing emissions may strongly depend on the degree the country has fully used its potential to realize technological break-throughs. Hence, the question is justified as to whether and under what conditions a specific strategy of governance fosters innovation? If a governance strategy, which neglects to take into account the technological implications of political choice, would yield a preference for the options that are cheapest on the short term, Dutch future economy may have to pay a price for political conservatism. The second reason has to do with considerations of both political rationality and academic curiosity: If the alternatives are available, why not explore them? Political history has shown a variation of governance strategies for catching up with technological progress. If there is anything these examples show it is that there has never been a market without government. Political rationality, as the concept has been defined by political scientists, cannot be confused with or restricted to defining process architecture. Political interventions articulate process as well as substance, in fact one cannot think of any political substance without a process shaped by it. To separate process from substance is to end up with nothing.

The aim of our study can now be defined as to explore what considerations, apart from technical feasibility, efficiency and social support may be relevant for governing the transition to a sustainable energy system. It is not the aim of this study to build a coherent policy framework. Instead, we think it more useful to explore different lines of argument that can be used to build a case for or to reject alternate courses of action. As we focus on the contribution that political science can make to the development of integrated knowledge on the energy transition, the study will focus on considerations derived from political theory and hypothesize how these political considerations may affect the potential of different technological paths. We hope that this exploration may somewhat broaden the scope of transition discourse and trigger the imagination of those involved in setting the policy and research agendas for sustainable energy.

This report is structured in the following way: Chapter 2 provides information on the scope and approach taken in this exploratory study. This chapter defines the general research problem, three research objectives and information on methodology. Chapter 3 reports on institutional characteristics found salient for a number of more or less promising energy technologies. Chapters 4 – 7 present four paradigms of governance derived from political theories and links these to the findings presented in Chapter 3. We distinguish the traditional paradigm ‘Governance by Government’ (Chapter 4), the (post)modern ‘Governance by policy networking’ (Chapter 5), ‘Governance by corporate business’, largely inspired by Schumpeter’s work on business cycles and technological change (Chapter 6) and ‘Governance by challenge’, inspired by a heterogeneous group of liberal and critical theorists (Chapter 7). Chapter 8 discusses how these paradigms relate to topics identified in the current stakeholder debate in the Netherlands.

2. Articulating paradigms of governance: scope and approach

This project explores the contribution that political theory can make to our understanding of what we refer to as 'paradigms for governing technological innovation'. The overall problem definition of the study is:

> How can political theories, especially theories that –both in a normative and an empirical sense- reflect upon the nature, characteristics and advancement of different types of democracies, contribute to our understanding of the prospects for a sustainable energy future?

This research problem is laid out into three objectives:

1. To identify institutional variables that may be critical for the potential of sustainable energy options;
2. To articulate paradigms of governance for technological innovation that articulate the institutional variables;
3. To identify issues and questions for the policy and research agendas.

The primary objective is to show that the focus of the exploration, i.e. that there is a relationship between the potential for technological trajectories and political institutions, matters in that it shapes the course of the energy transition. This is why in Chapter 3 this study explores specific institutional characteristics of competing technological options. In this chapter we use an inductive 'bottom up' approach.

The second objective of the project is to explore the relationships between these specific institutional characteristics and paradigms of governance from political theories. These paradigms may neither be mutually exclusive, nor do they (completely) match with the actual 'theories in use' that are found in the current energy transition discourse. The purpose of the exercise is not so much to reflect actual positions but rather to highlight paradigms that may be used to critically reflect on the current state of the debate.

The political theories we have used for this exercise share two characteristics that can make them look a bit odd to the readers who are not that familiar with theories from this discipline. Theories drawn from political and legal philosophies are particularly normative in character (e.g. the writings by J.S. Mill). Such theories articulate arguments about issues such as: What must be the limits of government vis-à-vis the individual rights of citizens? Is a participatory democracy better than one which is merely built on representation? Theories that are meant to be tested in empirical research may have normative implications too (such as the work by the Dutch political scientist A. Lijphart on so-called majoritarian and consensus democracies (e.g. Lijphart, 1999)). Then, there is a category of theories, which are built around a 'what if' assumption. The most famous examples depart from the assumption of economic rationality, M. Olson's work on the logic of collective action (Olson, 1971). All political theories do explicitly or implicitly deal with issues of political power and how a certain distribution of power between groups and individuals might be legitimated.

Obviously, an exploratory study like this one can only cover a very modest sample of the work that can be labeled as political theory. For the purpose of this project, theories were selected on the following grounds:

1. The theories have something to say on innovation; including the dissemination and use of knowledge;
2. Given the political-economics character of the subject, theories should articulate a view on the relation between state and market (theories not necessarily deal with the energy question, but their implications are found to be relevant);
3. Given the current trends toward liberalization and individuality, theories must specify the relation between state and individual;
4. A pragmatic consideration: the research group must be reasonably familiar with the theories under investigation.

From the start, we left out the international relations dimension, not because it would be unimportant, but by adding a new level of analysis it might complicate the exploratory exercise. The project's scope is basically the (nation) state level.

Following the broad range of literature on the articulation of policy argument, a paradigm is understood as a set of assumptions with respect to a certain policy problem, i.e. a problem which is supposed to require some sort of collective action. A paradigm of governance articulates a consistent line of argument, which includes causes and effects, goals and means, problems and solutions. In the chapters below, we try to present the different paradigms as much as possible in a similar way.

The linking of the political analysis to technologies or technology pathways makes this study a joint social and natural sciences undertaking. As a first step, the project team developed an analytical framework to link the political science and the technological literature (see Appendix 1). The framework was first used to analyze a number of energy technologies that are considered to be highly potential for the sectors industry, transport and households.

The third objective is to identify a set of questions for an interdisciplinary research and policy agenda which intends to seriously explore the interconnectedness of political, economic and energy technological variables characteristic for the energy system. For this objective, the report discusses the possible relevance of the respective paradigms with respect to current stakeholder discussions in the Netherlands.

3. Some institutional characteristics of energy technologies

First we explore as to how different sustainable energy options are characterized by specific institutional variables.

The project looked into some energy options that are widely considered fit to substantially reduce CO_2 emissions in the Dutch Housing and Construction sector and the Transport sector.[3] For the stationary sector, it looked into three supply side options, i.e. (1) all electric, (2) H_2 trajectories and (3) synthetic gas and then it looked into (4) demand management. For the mobile sector, it looked into (5) the fuel cells concept.

The choice to explore these options and not others may look somewhat arbitrary. However, given the exploratory character of this study, we consider the number and diversity of options sufficient for the purpose of the analysis. The main question addressed for these technologies does not relate to their technical and economic feasibility, which may vary, but is to see as to whether the options put forward have institutional requirements, which may (also) be relevant to distinguish paradigms of governance derived from political theories. This chapter first briefly describes the main technological characteristics of the options and then goes into their salience in terms of institutions.

3.1 Options

3.1.1 All electric

The *all electric* option is defined here by the production of low value heat using underground water storage and circulating the water through heat pumps. Electricity is centrally produced using natural gas and removal and underground storage of CO_2. As a variant, electricity may also be produced locally by renewables, e.g. solar PV or wind. This option is yet in an experimental stage for households, but for utility buildings it may already compete with conventional heating (and cooling) techniques. A technical requirement is insulation of the dwelling up to recent standards. Note that for this option, the dwelling is not anymore connected to the gas grid. In case of decentralized production, the surplus of electricity is either delivered to the grid or converted into hydrogen.

3.1.2 Hydrogen (stationary)

Hydrogen is centrally produced from natural gas, syngas or coal. The central infrastructure makes it possible to remove CO_2 and store it underground. It is brought to the

[3] This chapter is largely based on H. Jeeninga, Energie infrastructuur in de Gebouwde Omgeving, Vraagbeperking en Brandstofcellen in vervoer. (ECN Beleidsstudies, 2003). This is an internal working document written in the context of this project. It is further based on Back Casting exercises from the COOL project (Hisschemöller and Van de Kerkhof, 2000) and some preliminary findings form the current project Governing the Transition to a sustainable Hydrogen Economy (Hisschemöller and Bode, 2004).

dwelling through a central (natural gas or hydrogen infrastructure). Here, it is converted into heat and electricity by a micro-CHP installation. For this option, the electricity grid may not be needed anymore except perhaps for storing an electricity surplus.

3.1.3 Syngas

Syngas as the option is defined here, is gas produced through conversion of biomass. This option has the same characteristics as 'normal' natural gas in that it may use the same infrastructure. It can be mixed with natural gas. The currently available storage capacity for natural gas can also be used for syngas. Factors that may affect the sustainability of this option are a large scale supply of biomass for energy purposes (no competition with food production) and the actual possibilities to avoid the emission of other pollutants than CO_2.

3.1.4 Demand management

In conformity with the *trias energetica* one would first have to decrease energy demand, then use as much as possible renewables for energy supply and finally be as efficient as possible in using fossil fuels for the remaining part of supply. Demand management relates to the insulation of dwellings, i.e. walls, roof, floor and windows. A characteristic of this option is that measures are semi permanent; they will not be easily removed if better options become available. Demand management has to compete with less permanent supply options (HR or micro CHP systems). Consumers may be tempted to make short term investments in supply options and neglect demand management. At the same time, demand side management may be a necessary requirement for the successful implementation of innovative (low value heat) supply options.

3.1.5 Fuel cells in transport

The transportation sector is significant as it shows the highest increase in CO2 emissions in the Netherlands. Vehicle improvements are outweighed by a sharp increase in vehicle use. It is expected that even future improvements of the engine combined with modal shift (e.g. commodity transport over water) will be insufficient to stop the increase in emissions. Hence, a shift to zero / low emission transport fuels appears a necessary precondition for a reversal of the up going trend. Next to biofuels, hydrogen is one of the alternatives seriously considered by the EU.

Through a fuel cell H_2 is converted into electricity and heat. The vehicle will probably have an electric engine, but it is also possible to use hydrogen purely or mixed with other traditional fuels in an internal combustion engine. The hydrogen can be obtained at the gas station, like in the current (reference) situation. Hydrogen transport vehicles are still in an experimental stage. Much more experience has been gained with biofuels (such as ethanol or biodiesel). However, experience with hydrogen is rapidly growing. Instead of fuelling at the gas station, there is also an opportunity for home fuelling (link with option 1).

3.2 Institutional variables

There is much to say about the technological conditions and the costs of these options, as some look more feasible than others. If looked at from an institutional perspective, the following variables appear critical: The first variable relates to the question as to whether there is a strategic interest involved, such as an interest of national security or an interest that may otherwise relate to political stability. Strategic interests may urge for a specific kind of governance, because the protection of so-called collective goods is usually considered as one of the major functions of the (national) state. The most vital interest with respect to the stability of the energy system is considered security of supply. Therefore, we refer to this interest in particular. But other (social) interests may be thought of as well. Secondly, the question to be asked here is as to whether the option can be seen as a collective or a private good. Theoretically speaking, this dimension, referred to as collective-private overlaps with the 'strategic interest' topic, but here we refer to characteristics of the option with respect to infrastructure. In case of a collective good, implementing the option means that, basically, no one can be excluded from using it once it is available. So, in the Netherlands everyone can obtain natural gas, except for the small minority who is not connected to the gas infrastructure. In case of a private good, the option can be realized in individual cases without consequences for other individual cases or the entire system. So, an individual household or company may choose to go for a small scale self supporting energy system. As long as these cases remain limited in number, they will hardly affect the entire system. Apart from this collective-private variable, three other variables are considered salient from an institutional point of view, i.e. centralized-decentralized production, consumer sovereignty and externalization.

The findings from our analysis are summarized in Table 3.1 below. The plusses and minuses are based on the following considerations.

3.2.1 Security of supply

- The *all electric* option may contribute to security of supply, if, next to the central production of electricity:
  (1) Sufficient electricity is decentrally produced by a range of energy carriers including renewables and (2) the decentrally produced electricity can be transported elsewhere through a central grid. As will be discussed below, the consequences of the decentralized variant are far reaching;
- If *hydrogen* is centrally produced, which is assumed for this option in the Netherlands this will probably happen through natural gas. As hydrogen will replace the use of electricity it may be expected that the demand for natural gas will considerably go up. Today, the really big natural gas producing countries are not (yet) considered that reliable, which makes security of supply questionable. Only if, next to natural gas and biomass (see next), hydrogen producers will use coal and nuclear (or in addition wind), this option may contribute to security of supply;
- For the production of *Syngas* the Netherlands have to rely upon large scale biomass imports. As yet, it is not known as to whether such large scale biomass supply will be available over a longer period of time. Hence, this option may suffer from insecurity of supply;

- *Demand management* is supposed to contribute to security of supply in that it diminishes the use of scarce resources;
- *Fuel cells for the transport sector* will use hydrogen from natural gas or biomass or other sources. On the one hand, we might conclude the same as for hydrogen and syngas, which is that there will be a huge demand for potentially scarce fuels, but on the other, it might be concluded that the dependency on oil will go down, which is favorable for of security of supply. Given the reference situation, dependency on oil, we suppose that in this particular case there is more to say for the argument that security of supply may benefit from fuel cells in transport.

Apart from security of supply there may be other strategic interests, such as employment in existing energy related industries (refineries).

3.2.2 Collective – private and consumer sovereignty

- The *all electric* option is a collective good in that it will require a large extension of grid capacity. This will take an expensive endeavor, which may be in part compensated by the fact that the natural gas grid becomes redundant. In case of decentralized production, raising the grid capacity will also be needed if a surplus goes back to the grid. But consumers may also go for hydrogen. Consumer choice is limited but not absent. A mix of centralized and decentralized options are available;
- If *hydrogen* is centrally produced, the infrastructure makes it a collective good even if the H2 is produced in different ways by a variety of producers. Experts expect that the existing natural gas infrastructure is unfit for the transport of pure hydrogen. It is likely that the existing gas infrastructure should be modified or even replaced. This may require a huge collective effort at national level, even more so than in the all electric option. We expect consumer sovereignty to be minimal in this option;
- For s*yngas* the national infrastructure is available, but its maintenance and renovation are only feasible if a large majority of consumers uses gas;
- The option *demand management* may be considered to address a collective good but in practice, decisions are left to consumers or house owners. Obviously, owners of existing dwellings have most freedom in deciding upon insulation measures. Even if national or EU regulation is extended, this is likely to remain;
- Normally *fuel cells for the transport sector* are considered a private good. Consumers are free to decide on their means of transport, people can switch from one transport fuel to another and the producers are responsible for infrastructure. Consumers are not in any moral sense entitled to private transport. However, as recent upheavals in EU countries around gasoline prices indicate, there might be a public perception that availability and pricing cannot be left to the market.

3.2.3 Centralized – decentralized

This dimension largely overlaps with the former one because options that represent a collective good in terms of infrastructure requirements are normally produced and distributed centrally. However, private goods may be produced and distributed either decentrally (demand management), centrally (transport fuels) or both. In case of the all electric option, the low value heat and electricity can come either from the grid or can be produced by decentralized renewables, often owned by their users.

3.2.4 Externalization

As political institutions may serve to address problems of externalizing the costs of collective goods, which has also been referred to as 'free riding', we thought it useful to explore as to whether (large scale) implementation of the options under consideration may externalize social costs. For neither the options stationary *H_2 trajectory*, *demand management*, nor the *fuel cells* for transport vehicles we find significant externalization impacts, although we realize that choices with respect to infrastructure may drastically shape the opportunities for next generations. Because of the doubts as to whether the growing of energy crops world wide will compete with food production or distort natural protection, the large scale production of *syngas* for the domestic and industrial sector or, for that matter, biofuels for the transportation sector may run the risk of externalization.

It appears that especially for the option *all electric* the externalization effects may become critical, if consumer preferences shift from centralized to decentralized production. Basically, a single consumer's decision to become his own electricity producer may not have any consequences for others. However, this may become different once a large number of consumers would choose for the benefits of this option. As mentioned before, a significant share of electricity production by decentralized units may contribute to the collective good of security of supply. It should be noticed that this is only the case if a surplus of electricity can become available to all through the grid or another accessible store. The more people voluntarily choose for this option (assuming that it becomes attractive to them at a certain point in time), the more vulnerable the collective good infrastructure will become. On a warm day, decentralized production of electricity using solar PV may lead to a huge under capacity of the national grid. In response, the capacity of the electricity grid might be considerably extended or the electricity-surplus might be converted into hydrogen, in which case there should be some collective hydrogen infrastructure (option 2).

Apart from the considerable costs for infrastructure, an increased popularity of the *all electric* option in combination with decentralized production and conversion into hydrogen may bring serious difficulties to energy companies. The sales of centrally produced electricity may go down and this may also happen to natural gas and other energy carriers used for centralized electricity production. Even the producers of transport fuels may be affected, if domestically produced hydrogen is increasingly used for car fuelling. Hence, the vested interests in the energy system, those who are responsible for system's stability but also for the status quo, might all be negatively affected when through *all electric* a decentralized production of electricity and hydrogen would gain a considerable market share.

It might be possible that one of the major energy companies takes the initiative to embrace the decentralized variant by selling or leasing equipment to consumers. But even then, this option remains a potential threat to the stability of the system and for governing the system, because it will be extremely difficult to decide when infrastructural measures should be taken and how the costs must be shared. Hence, this option puts some interesting challenges to governance, as such a development may require something like a flexible response.

Table 3.1 Five energy options and their possible institutional implications.

	All electric	H2 stationary	Syngas	Demand	Fuel cells transport
Security	Yes Multiple sources	No 1 source	No 1 source	Yes	Yes
Coll-priv*	Yes	Yes	Yes	No	No
Centr-dec*	Both	Yes	Yes	No	Yes
Consumers	Yes	No	No	Yes	Yes
External	Yes If increase decentral	No	Yes If large scale imports	No	No

* + refers to the first concept in the dichotomy.

What can be learned from this tentative exploration of institutional implications of energy options?

- The first observation relates to the major consequences most options have for infrastructure. A choice for one specific infrastructure, e.g. an electricity, gas or hydrogen infrastructure may prevent an other option to develop. Given the scale of such a project and its costs, infrastructure choice requires a huge government involvement;
- The second observation is that some options have a head start in terms of infrastructural conditions. Fuel cells for transport may fit in quite nicely with the existing private fuelling infrastructure, although major investments may be required. Syngas requires good maintenance of existing national gas infrastructure, the central production and distribution of hydrogen requires to quite drastically adjust the natural gas infrastructure or even to create a complete new infrastructure. The option demand management is different from these three options in that it is not so much dependant on infrastructure, but in a sense creates infrastructure in all kinds of options that use low value heat (all electric option). All electric seems a very complex option in this respect. Central production will require major investments in grid extension. However, when decentralized production gains in popularity and very many (potential) consumer-producers get involved, other investments may be required;
- If we look at the implications for governance from the perspective of infrastructure costs in the long run, we may hypothesize that the lower infrastructure costs, the more *generic* policies will suffice, but the higher infrastructure costs, the more *specific* policies will come to be. Non-decisions at the political level will benefit options that can rely upon available infrastructure or private willingness to invest. Private willingness to invest will increase as the benefits of the investment return to the investor and do not leak to free riders, which may especially be an issue in case of large scale infrastructures;
- The analysis shows that almost all options are linked up with specific vested interests, but that certain options may exclude one another. Government choices are unavoidable. Where vested interests are not involved or may even be threatened, as in the cases of demand management and decentralized all electric, vested interests may be(come) resistant;

- The observations so far only take into account the strategic interests related to infrastructure. If we broaden the scope to security of supply, the picture gets more complex especially where the long term is concerned. Options that may be beneficial to security of supply seem to be much less linked to vested interests in the energy system than options that are risky in this respect, i.e. options that heavily rely upon large scale natural gas or biomass (syngas).

We would not endorse any claim as if this conclusion were supported by a thorough scientific investigation, but this is not the aim of this chapter and, at this stage, there is no need to make such claim. What we can conclude, however, is that our exploration yields legitimate hypotheses. These are worth investigating, especially because they contradict some major hypotheses common in transition discourse, i.e. that government does not need to choose in order to make the market work and stimulate innovation. More importantly, however, is that this chapter shows that, next to costs and social support, the competitiveness of long term energy options will be very much dependant on the governance strategy in place.

4. Governance by government

This paradigm claims that government should do what citizens or private actors cannot, which is to safeguard the public interest. In a democracy, the acts of government should be visible for the public at large, so that policy effectiveness can be evaluated by the electorate. Basically, a government has all means at its disposal within the rule of law.

Governance by government is based on two types of theories, which is reflected in a dual claim:

1. Private actors will not voluntarily adjust their behavior as to realize a public good. This statement can be elaborated and justified using economic theories of policy, politics and organization (e.g. Olson, 1971);
2. It is at the heart of (representative) democracy that public affairs are dealt with by an accountable public agent. This statement will be elaborated and justified using theories on representative democracy (e.g. Ezrahi, 1990).

Olson developed his logic of collective action as a critique on so-called group theory (Bentley, 1908), a radical orientation within American pluralist theory. The basic assumption in American pluralist theory is that groups organize themselves to voluntarily promote a collective good, such as 'good education' or 'a clean environment'. Each interest is, to some extent, represented within the political elite. Depending on the issue at hand, interest groups try to form majority coalitions. Given the overlap between groups and the variation of political issues over time, pluralist democracy offers a fair chance for all citizens to get something out of the political process. No group is completely excluded from participation and political power.

Olson rejected the assumption that people will *voluntarily* join in defense of a collective good (i.e. a group's interest). This is not because people are selfish. Also an altruist person would not act in favor of a collective good, if he makes a rational judgment. Olson explains this by pointing to the fact that the investments needed are not worthwhile, "since his own contribution would not be perceptible" (1971: 64). After all, you never know as to whether others would make a similar effort for the public good. The social isolation of individuals makes them hesitant to act, especially when the group and its interest is large. As one of the characteristics of a collective good is that, once it has been realized, no one can basically be excluded from using it, the most rational (in an economic sense of the word) behavior is to take a so-called 'free-ride', in other words, externalize the individual costs that need to be made for maintaining the collective good.

Indeed, there are circumstances which allow small groups or private parties to realize a public good. In this kind of situation, the cost-benefit ratio justifies action in the collective interest. We might think of so-called NIMBY (Not In MY Back-Yard) situations, where local groups (who do not suffer that much from individual isolation) are able to successfully resist unwanted facilities like nuclear power stations, thereby safeguarding locally collective goods such as a clean environment or a beautiful landscape. But in NIMBY cases, a small group has a much stronger interest to resist a collective good (such as an energy facility) than the community as a whole (all electricity consumers in a country or region) has to enforce it.

So, what Olson shows is the existence of what has been labeled social dilemmas, i.e. discrepancies between collective and individual interest.[4] The larger the public interest, the more it is vulnerable to suffering from free-riders who have a particular interest in harming the collective good. "There are multitudes with an interest in peace, but they have no lobby to match those of the 'special interests' that may on occasion have an interest in war. There are vast numbers who have a common interest in preventing inflation and depression, but they have no organizations to express that interest." (Olson, 1971: 166).

Olson's theory can be situated in a long tradition of thinking about the legitimacy of a coercive state vis-à-vis its citizens, of which Thomas Hobbes is considered one of the founding fathers. There is evidence to endorse that citizens are aware of the existence of social dilemmas and therefore tend to support government policies that make them behave in a way they would not voluntarily do. In exchange, citizens must be able to trust some basic qualities of the policy-making system: in particular, the benefits of government interventions should become visible for them. This is a necessary prerequisite for citizens to hold government accountable for its interventions.

Ezrahi (1990) stresses the role of the citizen as a capable witness in democratic politics (American politics being his main example), giving 'acte de presence' to actively observe real life experiments of social engineering. Science and technology are crucial in assisting democratic politics, especially since they help to depersonalize political acts and give them an instrumental meaning as a means to realize an end. What Ezrahi considers especially important is that democratic politics make it possible "to externalize the invisible, inward domain of motives in a visible domain of observable, knowable, rationally reconstructable actions and to subordinate the credibility of words and arguments to the apparently more public and objective tests of deeds and actions" (Ezrahi, 1990: 38). In this view, government acts, takes the initiative, experiments and, through trial and error and with the help of science and technology, works to realize an improvement of society. The analogy between governance and science as experiments is taken further. The citizen becomes an active lay-witness, like laypersons were invited to attend scientific experiments in the 17th and 18th century. Science may develop into what Lasswell (1951) has labeled the policy sciences of democracy, which was designed to assist policy-makers in addressing the major social problems of their time, poverty, unemployment, racism and education. In this vision of democratic governance, what citizens evaluate is not so much political rhetoric. What counts in the end is as to whether policies have worked in practice.

In order to realize a public good, the number of means, interventions and instruments that government has at its disposal is basically unlimited within the rule of law. Government may invent rules and regulations, raise taxes, create markets or close down factories. In case of innovation policy, it may establish generic policies but also support specific technologies; it may even perform as an entrepreneur. On one condition: the policy goal should be achieved and, in a democratic society, the public at large should have the opportunity to evaluate policy effectiveness.

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[4] But also compare metaphors such as 'the tragedy of the commons' (Hardin, 1968) or the 'prisoners dilemma' (Luce and Raiffa, 1957).

Ezrahi and others (e.g. Price, 1965; Castells, 1996) point to the experience with a rather extreme strategy of innovation, which can be fully justified by reference to the paradigm Governance by Government. This strategy (about the 1940s – 1960s) focused on the American aerospace and national defense sectors as niches for technological innovation. Huge funds were spent in national research labs and for the production of weapons. In fact, these sectors actually functioned as niches for the development and testing of new technologies. The strategy, labeled as 'governance by contract', served several functions at the same time: Firstly, the public-private collaboration served to develop, test and implement specific technical innovations, whereby government acted as what may be referred to as an 'early mover'. This innovation strategy was justified by the size of the costs and risks of the innovations, a risk no private actor could bear on its own. The strategy contributed to national prosperity and employment. But there was also another, more symbolic function: Through the involvement of private parties, they became integrated "as agents of public actions" (Ezrahi, 1990: 43). The private firms that contributed to the public cause in the US became to symbolize the collective action of the American people. So, 'governance by contract' was legitimized by an appeal to a strategic (national) interest and -simultaneously- created the conditions for people to feel involved.

As this innovation strategy shows, Governance by Government may, in spite of the liberal rhetoric of a free market system, focus on policies aimed at specific technology development and support. At that time there were two conditions that made the system work. The first was a successful appeal to an overriding collective good, security. This compelling national interest made it possible to bring to bear a seemingly unlimited amount of resources. The distribution of these resources among the private sector was based on no other considerations but one, i.e. to obtain given objectives. Policy was neither evaluated in terms of efficiency nor in terms of the quality of its underlying procedures. The policies shaped by 'Governance by Government' can be best characterized in terms of what Lowi (1972) labels 'distributive' policy. In this type of policy making, there is one actor which has so much power that it can make decisions without consulting other actors. The actor in power may itself establish the rules of reward and punishment and may itself choose to (re)allocate scarce resources. Given the power structure and its reward system, opposition against political decisions is very difficult.

The second condition for making this system work was linked to the first. Ezrahi stresses that the general perception of science and technology being impartial and objective helped to maintain the integrity of the system. Representational democracy is based on a dual objective, on the one hand to depersonalize political power and make it a 'neutral' instrument in obtaining political goals, while on the other hand to enhance and maintain a situation in which political actors can be held accountable and responsible for their actions.

For an understanding of the limitations of Governance by Government as a theoretical paradigm it is essential to note that a large consensus is a prerogative for any strategy that explicitly or implicitly draws upon it. Consensus relates on the one hand to the public goods (values) to be protected and on the other to the objective knowledge base available in support of specific actions. In a not that often quoted paragraph, Olson is the first to acknowledge that his theory on collective goods underlies this unrealistic

assumption of full consensus: “But the results obtained under this assumption are, for that reason, all the stronger, for if voluntary, rational action cannot enable a large, latent group to organize for action to achieve its collective goals, even with perfect consensus, then *a fortiori* this conclusion should hold in the real world, where consensus is usually incomplete and often altogether absent.” (Olson, 1971: 60) And he adds a warning for those who too eagerly may want to apply his theory with respect to state interventions in practice: “It is thus very important to distinguish between the obstacles to group-oriented action that are due to a lack of group consensus and those that are due to a lack of individual consensus.” In other words, coercion by government policies may only work if the citizens agree on the value and relevance of the public good under consideration.

Many have acknowledged the changing role of science and expertise in democratic societies. Rather than a means to impartially solve social problems, scientific knowledge has become contested and debated, especially where new technologies and their potential risks are at stake. The world wide controversy on the risks of nuclear power belongs to the most cited examples. The nuclear power debate had implications that go far beyond the area of technology policy. It has strongly contributed to a retreat of government in its capacity to support specific technologies. It has led to reconsider the relevance of public participation. And it has shaped a more critical attitude with respect to the often privileged position of expert networks in decision-making, giving more attention to so-called practical or lay knowledge.

Notwithstanding its built-in limitations, it may be too early to state that for Governance by Government the book is closed. In case of a shared awareness and a high sense of urgency, governments may deviate from their course of liberalization and privatization and take the transition of the energy system more in their own hands. The paradigm Governance by Government would be specifically fit to manage a collaborative attempt to implement energy technologies which require huge infrastructure investments and major potential environmental risks. Also today, its appeal to public as well as private actors is the promise that collective action, a joint effort to invest as ‘early mover’ in a pre-competitive stage, may be effective in realizing a transition path to a sustainable energy system.

5. Governance by Policy Networking

This paradigm claims that the traditional instruments of the state to control and shape society do not work anymore. The power of the traditional nation state is weakening. Instead of enforcing its will on society, the state may govern together with private actors to jointly realize the public interest. Therefore, government facilitates the formation and maintenance of policy networks consisting of socio-economic actors. These networks are supposed to have the knowledge, the power and the inclination to foster some public interest, including the transition to a sustainable energy system.

In the Netherlands this paradigm appears to be dominant. It is defended by a great number of policy scientists. Generally speaking, the assumptions that underlie this paradigm of Governance by Policy networking can be summarized as follows:

- There is a shift from 'government' to 'governance'. Whereas 'government' refers to a monocentric interventionist perspective, the idea of governance refers to a polycentric model, which envisions concerted actions by decentralized actors, each of which has only limited coercive capacity;
- Multi-layered governance[5] refers to the way policy making at different levels (local, national, European, global) has become intertwined. From a normative perspective, this concept refers to the need for better coordination and collaboration between different levels of governance, given its bad track record, which comes out from many studies on 'implementation';
- A third element in the concept of governance is the idea that, next to governments, stakeholders from 'civil society', especially the business communities and the environmental and consumer NGOs (have to) become partners in governing. There

[5] The term "multi-layered" is here being used to in the sense of the French historiographical school, e.g. Braudel (1979). Present states of affairs are seen as resulting from different and stapled historical processes of different tempi, (longue durée, histoire conjuncturelle, histoire evénémentielle). Cox (1995) calls them "historical structures". In some fields, like law, it is easy to see that some "layers" nearly disappear, others are being overgrown by new layers, and others coexist. Governmental institutions can also be considered historically grown, layered historical structures.
Multilevel governance is related to that concept in the sense, that governance can be seen as being exerted on different levels (local, Geländer, national, European, global), working together, but also with tensions and counter to one another. But the term multi-level governance is just an institutional denominator, which can lead to overlooking the historically different developments that go behind those levels. The interrelatedness and dynamics between "local", "national", "European" and global levels differ greatly due to historical reasons between e.a. the Netherlands, Belgium, Germany, France or Spain.
Related but not identical to multilevel governance in the sense of cooperation and/or coordination between institutional government levels is the use of a multilevel model within a systems approach of technological innovation, called transition management (e.g. Rotmans, Kemp, Arentsen). In this approach a three level model is being used: niche level, a regime level and a landscape level. (similar as micro, meso and macro levels). And multilevel governance of system innovation processes, managing transitions, is then managing the dynamics between these levels (Rotmans, 2003: 63).

have always been critical sociologists and political scientists who have studied participation as related to the exercise of power, e.g. of the (international) business community. However, what is new in the current situation is the notion that participation can be part of a smooth management process rather than a struggle for power. Participation is considered necessary for good governance because, in the case of complex (unstructured) problems, the traditional instruments of top-down regulation are supposed not to work anymore. The idea of 'governance by networking' may be especially strong in The Netherlands (e.g. De Bruin and Ten Heuvelhof, 1999; Glasbergen, 2000). with its traditions of enlightened corporatism (polder model) but this is an international trend as well. Participation becomes associated with co-production rather than with opposition and with workshops rather than with public hearings. This is observable in national policy making as well as in international environmental negotiations;

- One of the main factors responsible for the participatory trend in environmental policy is the changing role of science and expertise. The status and privilege of scientific knowledge has declined and is likely to decline further, as (environmental) problems are conceived of as increasingly complex. It is widely recognized that problems are not objective givens and values cannot be separated from facts. The last decades have shown a growing interest in 'lay' or 'practical' (stakeholder) knowledge and its relevance for environmental policies. The tensions between the need for sound scientific expertise and the contested character of knowledge, have contributed to an increasing popularity of participatory approaches in integrated environmental assessment (e.g. Hisschemöller, Hoppe, Dunn and Ravetz, 2001);
- At the level of theory, many policy scientists have noticed a shift from an interest-based orientation to one based on discourse and social-constructivism. Diverging stakeholder views are not so much explained by conflicts of interest, they are supposed to originate from conflicting conceptions of reality, held by stakeholders who may – apart from other differences - operate at different levels, the global, the national and the local.

Some striking developments during the last decades in energy policy worldwide can illustrate the rise of this paradigm in theory and practice. Traditionally, energy policy has been in the realm of national government, especially where issues of environmental risk are concerned. Until recently, many national governments owned companies with the goal to produce and allocate collective goods and services, such as energy. Especially the building and exploitation of large infrastructures became a nation state responsibility, including the funding and the legal and coercive framework needed to implement and maintain the quality of infrastructures and the handling of collective resistance against unwanted facilities. In the Netherlands, national government has, in the case of natural gas, shared the ownership and exploitation of natural resources, but the import and distribution of transport fuels have always been a private activity. In case of the allocation and protection of collective goods and services that are associated with a national interest – in 20th century's industrial states energy being a typical example –, political systems (states), even the most pluralist ones, have acted as monolithic actors vis-à-vis citizens and business. This is also true for The Netherlands, where major decisions related to energy policy, such as closing down the coal mines in South-Limburg during the 1960s (Moharir, 1979), the transition to natural gas (Correljé and Verbong, 2002) or

the decision not to build new nuclear power stations (Hisschemöller and Midden, 1990), were based on a political consensus. Open conflict was avoided and where this turned out impossible as in the case of nuclear power, it resulted in non-decisions c.q. inaction.

Although theories on *governance* are of more recent date, we may like to link this concept, and especially its focus on collaboration and consensus, to political theories in the corporatist tradition. The Dutch political scientist Lijphart (1967) introduced the concept of 'accommodation politics' in order to capture the Dutch political system as it had evolved during the first part of the 20th century (1917-1967). In later publications, this type of system has also been labelled the consensus model of democracy in contrast to the majoritarian model based on the "winner takes all" principle that underlies the electoral system in the United Kingdom. Accommodation politics differs strongly from American pluralism in that it applies to a social system which lacks so-called cross-cutting cleavages (overlapping social interests and groups). The social system is dominated by conflicting values if not social segregation. In fact, the social, cultural and political landscape in Netherlands was dominated by 'pillars', representing different religions and ideologies. None of these groups could, on itself, build a majority government. A competitive pluralist approach would either yield oppression of minorities or the political system would fall apart. The democratic method fit for this particular situation would be a kind of elite rule based on a compromise among the leaders of the various cultural, ethnic or religious groups. This compromise includes several rules of conduct that are crucial for the stability of the system, such as the principle of consensus in matters of national importance (which implies a *de facto* veto power for the blocks involved), an agreement to disagree in other matters and secrecy vis-à-vis the rank and file. One basic characteristic is the low level of participation in this type of democracy. Participation may easily lead to polarization and, in case of ethnic or religious conflict, the destabilization of the political system or even civil war. So, what makes this model differ from other models of democracy, such as the American model as described by Ezrahi (1990, see Chapter 4), is the absence of competition among the political elites (Huntington, 1981). It is considered a vital interest of the various elites as well as of the entire political system that the rank and file takes a somewhat deferent position with respect to politics.

Policy as accommodation may have proven to work in cases of irreconcilable values, such as culture, ethnicity or religion, it may also work in other issue areas such as environmental risk. Even in case a society is not segregated at all, it may happen that environmental conflict tends to polarize because of antagonistic values, like in the cases of nuclear power, GMOs or the protection of traditional landscapes and natural areas. Conceptions of risk may even be linked to diverging cultures.[6] The rules of the game in this type of policy are (1) to agree that the conflicting values at stake are legitimate and may not be harmed, (2) try to seek consensus on what may be considered a means rather than policy ends. Means can be understood as all kinds of vehicles that may help to move away from a deadlock position, such as the application of certain laws and proce-

[6] Whereas Douglas and Wildavsky in their famous *Risk and Culture* take a Schumpeterian position, insisting that dialogue between cultures is a dangerous utopian error, Schwarz and Thompson (1990), applying cultural theory inter alia to Dutch environmental policy, argue for a dialogue between cultures.

dures, the political conception of general policy framework documents that seek at integrating competing values (ecology and economy), the setting of environmental standards, the discussion on and application of policy principles, such as the precautionary principle, as well as concepts used to enhance dialogue and to establish a shared discourse, such as sustainability, ecological footprint or transition management. Policy may become more abstract and symbolic rather than specific. The basic justification is to advance a dialogue among parties with strongly divergent views. This may on the one hand build trust and help to meliorate antagonistic positions, and on the other create a shared framework for understanding the complexities of the situation at hand.

Governance by Policy Networking may be considered a corollary of Accommodation politics especially because of its focus on consensus formation between political actors and stakeholders. The Dutch model of environmental agreements between government and business have become famous and are considered an example by many international scholars. One of the most important agreements, as far as the energy transition is concerned, is the benchmarking agreement: Major Dutch corporations have agreed to maintain their leading international position in the field of energy efficiency, while in exchange Dutch government has promised not to take reduction measures that could be harmful for the position of Dutch industry in international competition. This agreement does not affect the level of emissions, as in a period of economic prosperity emissions can go up in spite of improved energy efficiency. Transition management may also be considered to fit in nicely with the Networking paradigm. Consensus on transition goals can be considered a means to stimulate the private sector to take its social responsibility without specific government regulations. However, behind the scene, the possibility of regulation is always there, but the likelihood thereof is not that big, given the shared recognition that parties are dependant upon one another in order to move forward.

Another and most remarkable feature of the policy networking paradigm in practice, is the focus on collaboration and, which is the other side of the medal, the lack of competition. To the extent there is competition between transition views at the political level, the controversy is rather symbolic and does not seem to have much bearing on practice, an example being debates on (long-term) environmental targets. And although at the level of specific solutions ‘creative competition’ (Teisman, 1997) may be part of the game, Governance by Networking suggests that sharing expertise can lead to the best results both for separate companies as for national economy. In the field of energy this seems to be confirmed by the very high correlation found between the overall energy-efficiency of the economies of 36 democracies and the degree of consensual characteristics of these democracies, a correlation that is unaffected by the introduction of the level of economic development as a control variable. (Lijphart, 1999, 297).

However, Governance by Policy Networking may be also vulnerable to the critique that it yields conservatism rather than innovation. Some empirical evidence has been produced by Eberg (1997) in his comparison of waste policies in the Netherlands and Bavaria. More important than scattered empirical evidence, though, is the argument that can be derived from political theory itself. The networks to be governed become part and parcel of the governance setting itself, in other words; they become institutionalized. Rather than a means to an end, the networks may become ends in themselves. Hence, the networks may be resistant to innovative views and actors. Even an independent actor as the Dutch Council for Space, Environment and Nature Research (RMNO) reflects some

concern with respect to the input from non-institutionalized actors in the policy networks: "For system innovation, not dominant knowledge is important. This implies that the configuration of knowledge producers must be different for a transition network as compared to already existing (policy) networks. Innovation is impossible without new, crosspatch thinking, *but this should be restricted in order to yield results.*" (RMNO, 2003, translation and italic by the authors).

In the absence of rival views networks may extend and reproduce specific discourses. Apart from their important symbolic function, discourse may also perform as an important mechanism for inclusion and exclusion. So, it may be hypothesized that Governance by Policy Networking may have the unintended effect to prevent what it aims for, i.e. the stimulation of technological innovations. In a recent study on the social and political implications of the project The Greenhouse as a Source of Energy initiated by the Innovation Network and the sector, the first author of this study concludes that perhaps the most significant threat for this technological break-through concept may not be lack of support in the sector, but a government based discourse which seems to a priori ignore the feasibility of this concept for the decade to come (Hisschemöller, Ravensbergen and Minnesma, 2003).[7]
The report states that "doubts with respect to the feasibility of the concept are likely to be based on implicit assumptions that go beyond the scope of the technological concept itself. Can government support technological innovation in an era of liberalization? Then, Dutch energy discourse reflects the view that solar based innovations are still far ahead of us" (Hisschemöller, Ravensbergen and Minnesma, 2003: 18). The report concludes that, in spite of the political support already there, transition discourse may provide serious obstacles for this system innovation. These may effectively be countered by lobbying from the sector rather than a transition dialogue.

To conclude the discussion on this paradigm, it can be said that it has become dominant in policy science and policy-making circles in quite some countries including the European Union. On the one hand, it is being welcomed as an alternative for top-down government and political polarization. It is expected that power sharing may foster the sharing of knowledge and hence, technological innovation. On the other hand, questions rise with respect to the institutionalization and discursive impact of the networking. A compromise oriented approach may neglect rather than enhance opportunities for innovation.

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[7] A key concept in this government based discourse is cost-effectiveness, which suggests a realistic attitude vis-à-vis the legitimate interests of business. But unfortunately, cost-effectiveness is not an unambiguous concept; it can be measured in many ways and sometimes it is not being measured at all.

6. Governance by corporate business

This paradigm claims that the private sector, especially corporate business has the power, the knowledge and the ability to innovate and even make transitions happen. Schumpeter's theory of long waves in capitalist production is particularly interesting to support this claim.

In his monumental work Business Cycles (1939) Schumpeter discerns three interrelated cycles of the capitalist economies:[8] Kitchin cycles, that lasted from top to top 3 to 4 years, Juglars, that took 8 or 9 years and Kondratieff-waves of about 50 years. Much has been written about his suppositions and the statistical flaws with long-term statistical time series. But for us it is more interesting to learn about the driving forces behind these movements. Much more than other economists Schumpeter focused on Entrepreneurs and Innovation.

An entrepreneur is a person that sets up a New Production Function, a new combination of production factors.[9] It all evolves around Leadership, an insight neglected by Marx and the other classical economists according to Schumpeter. One can ask oneself if the many failures in the Westerns countries of the big privatization projects of public utilities aren't due to the neglect of that insight, because those leaders were the former civil servants in many instances[10] Nothing keeps us from considering energy as one of the production factors that play a vital role in New Combinations. New Combinations are set up to make profits.

Competition between private companies is central in Schumpeter's view on technological innovation. Even entrepreneurs that have reached monopoly-like positions will and have to keep on innovating in order to prevent themselves from loosing their position in the long run. In what he calls Trustified Capitalism they are permanently making Research and Development efforts to maintain their leading positions. An additional aspect of Schumpeter's perspective is that simple cost-benefit calculations are considered inadequate. Those calculations are misplaced as far as the question of creating sufficient dynamics in the energy sector is concerned. His concept of "creative

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8 The Austrian American economist and political scientist Joseph Schumpeter is to be considered the latest of the representatives of the so-called Austrian school, the group of economists that ended with their theory of marginality the efforts of the classical economists to build a theory of value of all economic goods and services, based on production costs and in the end on a labour theory of value.

9 He or she must be discerned from the Manager, whose role it is to arrange a production function and also from the "Capitalist", whose function is to carry risks. (Schumpeter, 1939, p. 104).

10 One can also wonder if the *managerial revolution*, that Burnham (1941) already sketched in the forties hasn't evolved nowadays into a system where most dominant companies are run not by Entrepreneurs but by Managers, who succeeded in switching off one of the powerful mechanisms of the capitalist system: the risk to have to pay for their own mistakes, which was for Schumpeter "one of the causes of the efficiency of private business". (Schumpeter, 1939, 1041).

destruction"[11] denotes that destroying production capacity – at a too early stage seen from the calculators' perspective, is an inevitable consequence of the capitalist dynamic. It is a sign of insufficient dynamics if governments and vested interests would succeed in letting the existing production functions live their physical lives.
The shorter waves build up the long ones. The upward phase of those waves consist of steeply rising shorter cycles and flat recession phases, while the downward phase of the Kondratieff consist of flatly and shortly booming cycles and long and steeply recession phases. The expansion phases of the long waves are caused by the introduction of new technologies in many sectors of the economy, which occasionally causes disruptions, losses of dominant market positions, but also new equilibriums.

> "In every span of time it is easy to locate the ignition of the process and to associate it with certain industries and, within these industries, with certain firms, from which the disturbances then spread over the system". (Schumpeter, 1939: 102).

Schumpeter expected that the capitalist way of producing would end, (Schumpeter, 1939: 908), not a very strange expectation in the light of social crisis and of the international tensions in the 1930s. Marx believed the end to be the consequence of inherent tendencies within the economic system. Crises and cycles were the expression of the "law" of the tendency of profits to fall and the momento mori of the system. Schumpeter however pointed out that capitalism could break down as the consequence of the system's tendency to create a social atmosphere hostile to that system. He also believed in the viability of other systems: the corporatist system of Nazi Germany and the collectivist system of the Soviet Union. Where private property of the means of production had come to an end and the role of entrepreneur, capitalist and manager was taken over by the state, the economic process would not go through cyclical movements any more. Those views are important in the sense, that he postulates that using a "socialist" set of instruments in a capitalist environment is counter-productive.[12] The last section of Business Cycles deals with the "disappointing Juglar" from 1936 onwards. In his view, the fact that the cycle of those years in the US doesn't run the way it should according to his scheme, is a consequence of the use by the Roosevelt administration of socialist instruments in a capitalist context. As long as those instruments are complementary to innovative investments by the private sector, there is no problem. As soon as public investment becomes a substitute and halts private investment, it's a different matter.

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[11] Schumpeter introduces *creative destruction* for the first time in his Capitalism, Socialism and Democracy (1943). It resembles Marx' concept of moral versus physical decay of machines. It is the insight that the quest for technological rent, that is the entrepreneur's preoccupation, will lead to a technologically spoken unnecessarily fast destruction of existing production capacity, but just that is an essential precondition for the dynamics of the capitalist system.

[12] See also (Schumpeter, 1943: 55, Schumpeter, 1939: 1037), where he speaks of "*The attempt to run capitalism in an anti-capitalist way*".

More specifically the electro-technical industry, the automobile sector and sectors like the rubber and chemical industry behaved as Schumpeter expected. [13] So, there was a reasonable expansion in many important sectors, together with many small innovations. But as Schumpeter goes on, the electricity sector lagged far behind and if it did expand it was via public works, and disappointingly little via "privately owned public utilities", (ibid). The downfall of private initiative in the electricity-producing sector was in his opinion caused by the anti-capitalistic character of the measures from 1936 and '37 that had their effects in 38/39. "The Public Utilities Holding Company Act endangered the American solution of the fundamental problem of power finance" (Schumpeter, 1939: 1043). That was because of fear on the side of private initiative for unfair competition from public companies.
So it is not so much the existence of public investments in the power sector that worries him: "The development of new sources of power and their competition with the old ones is of course *part of our process* (our italics) and not an impediment to it. In principle it is immaterial by whom the new sources of power are developed, whether by public or private enterprise." (Schumpeter, 1939: 1043). It is the political context and the modalities of the state intervention in the power sector that cause the problems. "Executives and investors would have had to be completely blind to the political forces that they were being marshaled against, if they had been prepared to take the responsibility for, or cooperate in, new investment on a large scale" (ibid).
How then, can and should government shape innovation?

As far as corporatist systems are concerned Schumpeter points to the enormous investments done by Nazi Germany in energy production technology (via Braunkohle AG), based on hydrogenation that were motivated by policy of autarky. The only problem he saw was that this policy was accompanied by prohibiting investments in other energy technologies, ruling out competition between alternative technologies (Schumpeter, 1939: 975). He states that, if there is a strong state, that is not subject to control by specific group interests, but has clear goals, a well-directed use of monetary means, that prevents waste and inflation and if the use of means is additive to what the entrepreneurs would have done anyhow, a state *can* play an entrepreneurial role.

Schumpeter defines capitalism as a system, in which entrepreneurs carry out innovations with the help of borrowed money[14]. States should not inhibit the functioning of that system. States can create infrastructural preconditions, that are additive to the innovation processes that are going on anyhow. In that system business is primary relevant because it drives technological innovation and considered capable of implementing change in these matters.
Schumpeter's plea for a leading role of corporate business especially in capitalist societies is to some extend reflected in recent publications from various sides. Jeremy

[13] "Having thus satisfied ourselves that the processes which in the past used to carry prosperities have not been absent in the present instance, we have established a right to speak of a Juglar prosperity and to infer from experience that it would have asserted itself without any external impulse being imparted to the system by government expenditure or by any other factor". (Schumpeter, 1939: 1026).

Rifkin's *Creation of the Hydrogen Economy* (2002) tends to bear Schumpeterian traces. His long-term view on the economics of energy production and consumption systems, his neglect of cost aspects, his focus on returns, investment possibilities and on the initiatives of big businesses all witness that inspiration.

In some significant respect, also Shell Internationals scenario study (2001) echoes the Schumpeterian view. The scenarios recognize the importance of climate reduction targets, the Kyoto protocol and other government policies and interventions. But what counts in the end is how the energy companies address international developments and public demand. This claim is warranted by the observation that the driving force behind corporate strategy is consumer demand. To take this line of argument a little further, the bigger the corporation, the more it tends to focus on the preferences and concerns of the general public. From this perspective, climate policies are by far not the only relevant drivers to a sustainable energy future. Indeed, one Shell scenario, called Business as Usual, is based on considerations such as cleanness, security and ultimately sustainability. The development of renewables like solar is important in this perspective. The other scenario, called The Spirit of the Coming Age, focuses on the development of (natural gas based) hydrogen, not so much on climate or energy considerations, but because a superior technology is preferred by the consumers. The fuel cell becomes popular because of the huge increase in consumer comfort. Cost considerations do not play a remarkable role in any technological trajectory for the long term, in spite of what is so often assumed in public policy statements.
In conclusion, it might be appealing for politics to follow (corporate) business. This would not mean that government has nothing left to do. To the contrary, companies know exactly when and how to find government if they need support for some activity, which embodies both a private and a public interest. Some might argue that this is already a long-standing practice. For others, the idea that corporate business works to a sustainable energy future might sound very unrealistic as long as the world controls and uses relatively cheap oil and other fossil fuels.

From a government perspective, the idea that corporate business might lead the transition to a sustainable energy system might also be frightening. Increased practice of accountability vis-à-vis the public and openness to some form of public control on the side of corporate business, may mitigate suspicion and distrust on the side of the general public. Especially where governments lack the knowledge and the ability to act adequately and where corporate businesses has a stake in public trust, government may loose relevance. A recent example has been provided in the area of standard setting for food production. The European retail sector has joined into EUREPGAP, the European Retailers Working Group on Good Agricultural Practice. This institution sets and controls standards for the quality and safety of food, thereby actually taking over a public function (Van der Grijp, 2003). Although this has not been documented, it might very well be that recent crises in European agriculture have triggered this initiative. Especially the BSE scare in the United Kingdom in 1996 (Jasanoff, 2001) may be considered significant in this respect. As Jasanoff reports, British government was

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[14] "We have to define that word which good economists always try to avoid: capitalism is that form of private property economy in which innovations are carried out by means of borrowed money" (1939: 223).

paralyzed by this crisis, as she had tried to keep the facts out of publicity even when this was no longer an option. The public panic was such that the retail sector took over the initiative. It not only informed the public about the risks of eating beef but also, in its own interest, started to perform as a public agent vis-à-vis the public. Energy companies, who serve a public function quite similar as the retail sector in this case, might initiate actions with respect to security of supply or the quality and safety of energy in a crisis situation as e.g. Shell did during the oil crisis in the seventies on behalf of the Dutch government. So, the risk (or blessing?) inherently linked to the paradigm Governance by Corporate Business is, that, in the end, in our type of societies politics is rendered irrelevant as far as technological innovation is concerned.

7. Governance by challenge

The main policy claim within this paradigm is that government should address rules, regulations and privileges that may stand in the way of innovation. Government interventions in the market may be justified if they actually improve competition between existing and new options and strengthen consumer sovereignty. This claim is supported by:

1. Theories on technological innovation (lock-ins and lock-outs);
2. Critical social and political theories that focus on the knowledge implications of power relationships in society;
3. Methodological notions developed in policy science on 'cognitive impairment';
4. Liberal and radical theories that discuss the risks of a too powerful state.

Literature on technological innovation has pointed to the importance of technological regimes. A technological regime links scientific and technological knowledge and expertise to a set of applications and actors or sectors of economy. Innovation can occur within and across technological regimes. The inclination to draw upon knowledge and knowledge applications available in a regime may lead to incremental growth within a given technology path, which is referred to as 'lock-in'. When knowledge from the outside is permitted access to a regime, we may witness non-incremental innovations, leading to new technological concepts and new applications.

Especially in the case of pervasive innovations, i.e. technological innovations that permeate many sectors, there is an interplay between technological, social and cultural change. System innovations, or transitions (Rotmans, 2003) are difficult if not impossible to influence (Arentsen e.a., 2002). Characteristic for recognizing system innovation as compared to incremental growth or system optimization is that new actors and knowledge from 'outside' step in and, in certain occasions, old actors may step out.

The same line of reasoning is present in the so-called technology dynamics studies as well as in evolutionary economics based on the insights of e.g. Dosi, Nelson and Winter. Especially the notion of technological paradigms implies a process of locking-out technological possibilities from innovation processes that do not fit within dominant paradigms be it by a cognitive or communication process, by technological regime characteristics or by networking exclusion mechanisms.

It is stressed that in those processes of technological development, innovation and diffusion, vested interests specialized or "locked-in" in the old technologies cause resistance to the adoption of new technologies. (Mulder, 31).[15] From a political and

[15] Joseph Schumpeter, again, in his work Business Cycles in many ways paved the way to the technology dynamics and evolutionary economics research by stressing the discontinuities between the dynamics of the real world and the neo-classical reasoning. Time lags, expectations, rigidities, technological lags, different types of technological innovations were all to be studied according to Schumpeter. In a capitalist surrounding innovation processes tend to be unequally distributed in time, destructive in its consequences for sunk investments etc. But still, as we have seen, a state should not try to interfere in this processes, because of its inability to see and exploit new technological possibilities.

institutional perspective, this kind of change does seldom go without struggle. Smooth system innovations seem a *contradictio in terminis*. As Castells (1996) recognized: the breakthrough of new pervasive technologies does not take place within the dominant networks but in networks that are peripheral at first and even based on deviant subcultures. Castells and others thus point to a characteristic of technological networks that is not mentioned too often, i.e. that innovation is accompanied by a new articulation of power. So in an analogy with Galbraith's (1952) concept of countervailing *power* the concept of *countervailing* networks can be introduced. Such networks may challenge and undermine the dominant technological regimes and the institutions through which they (inter)act.[16] Basically, dominant institutions serve to assist stakeholders with vested interests in sunk investments to avoid competition and, thereby, postpone pervasive innovation.

From the perspective of Governance by Challenge, the institutions that facilitate technological regimes cannot be labeled as merely technical or economic but they are political as well. Studies in political economy and international relations from a Marxist perspective, have focused on the relationship between economic, political and technological (f)actors. They have found that specific socio-economic and political conditions, including labor relations, dominant modes of production, styles of policy making and international alliances, are being expressed and legitimized in quite coherent concepts of control. Concepts of control reflect a specific view on a nation's general interest. The networks which establish and develop a concept of control recruit their members from different business interests, different political parties and different knowledge systems. Although such concepts cannot be directly related to specific sectors, business or class interests, the specific content of these concepts reflect their origin. In the process of political and ideological struggle concepts of control become hegemonic as they succeed to legitimize itself as an expression of *"the" general interest* (Bode, 1978; Overbeek, 2004; Van der Pijl, 1989).

In this tradition technological developments are not just answers to specific consumer needs, but also to problems in the management of societal conflicts and contradictions (Roobeek, 1988; Tulder & June, 1988). Examples of such concepts are Fordism, New

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So by calling into question the smooth world view of the neo-classical tradition (at the end of the crisis years of the thirties of last century) and by endogenizing technological change, he paved the way to a new field of research. (Mulder, 2003, chpt. 2 and Mulder, De Groot and Hofkes, 2001). This new field of research originates from the beginning of the eighties, also a period of economic stagnation, in which dissatisfaction with neoclassical reasoning, especially the Solow and Swan growth model, Harrod and Domar and the Cobb-Douglas production function, grew again. Nelson and Winter and Dosi fell back on Schumpeterian insights, half a century later! However, by at least in a capitalist surrounding excluding government from interfering in the field of technological development and innovation Schumpeter did not stimulate the idea of transition *management* from outside the business world. May be that is why Schumpeter is sometimes not very justifiably criticized by authors in the field of technology studies. (e.g. Luiten, 26).

[16] In political science literature the concepts regime and institution might be used interchangeably, as they both refer to the formal and informal rules of the game that shape actors' behaviour. In our vocabulary and in contrast to some other definitions (Young, 1999), the concept of institution may also be used to point to the behavioural impacts of organizations.

Deal and Keynesianism in the thirties and in the aftermath of the Second World War, also referred to as *corporate liberalism*, a form of governance that functionally can be connected to productive capital (Van der Pijl, 1984a). Afterwards, the stagnation period from the seventies and eighties of the last century paved the way to a new hegemonic concept, which combined flexible automation technologies, neoliberalism and globalization. This concept has been linked to money capital and financial capital (Overbeek, 1991). On the one hand the production technology of Fordism and the development of Scientific Management were *made possible* by technological breakthroughs, such as the use of electricity instead of steam and especially the *decentralized* use of AC-electricity in factories (Geels, 2000). On the other hand, Fordism functioned as a social-political project. It offered higher wages enabling the workers to buy the products of their higher productivity in exchange for degradation of craftsmanship (Braverman, 1974) and in exchange for cooperation between labor unions and business leaders. Fordism developed in the United States in the interwar years and was implemented on a national scale by New Deal Policies. It was initially blocked in Europe. After the second World War Fordism and Open Door policies became dominant in Western Europe helped by the Marshal Plan (Van der Pijl, 1984).

The provision and use of cheap and *centrally generated* large scale electricity for the mass production of goods for mass consumption has always been seen as inherent to Fordism (Pacey, 1983 and 1992). It may even be hypothesized that in the sphere of energy generation in the mobile and stationary sector the major technologies in the field of production and distribution are still very much based on the Fordism, New Deal and Keynes paradigm, the concept of control of *productive capital*, despite the upcoming of a new dominant neo-liberal paradigm.[17]

A critical aspect of the notion of system- or pervasive innovation, articulated in both technology studies and in studies by critical political economists and social theorists relates to the question why and how power relations interfere with innovation processes. At first sight, this question may look a little bit odd. As those innovation processes tend to undermine vested interest positions, the 'powers that be' would be more than likely to resist them. For that reason, they may use their resources, including their privileged position within the networks of business, policy and expertise, to keep (potential) challengers in a position of disadvantage. However, this is not the entire story. The other and perhaps more important part of it is that, given the institutionalization of technological regimes, or, given the paradigmatic function of concepts of control, the actors involved may not be able to see or recognize specific innovations. For this type of cases, the famous American political scientist Lindblom (1997) has introduced the concept 'cognitive impairment'. This concept does not refer to a person's intelligence but to the way institutional conditions shape peoples' capacity to take notice of what happens in the world around them. Cognitive impairment is therefore considered a huge impediment for initiating change. In practice, resistance to change on the side of powerful stakeholders may have a dual background, on the one hand they do not *want* it, on the other they

[17] The development and interplay of Fuel Cell, Hydrogen and Internet technologies, that enable so-called Distributed Generation (US), or experiments with the "Virtuele Energy Centrale" in Germany and the Netherlands e.g. can cause the rise and breakthrough of new technological as well as political paradigmatic views in the energy sector. (Rifkin, 2002; Lovins, 1999).

don't *see* its opportunities. That cognitive impairment is an important institutional factor in shaping the viability of sustainable energy options is illustrated by the observation that, in spite of the fact that international epistemic communities have come into existence, national states, even within the EU, show quite some variation in this respect. It is likely that historical and political factors rather than technological ones can explain France's preference for nuclear, Germany as forerunner with respect to biomass and the US preference for fossil. What may remain unnoticed in one country or within a cross-national paradigm, can become a success story of innovation in another.

Hence, a transition strategy must be aimed at overcoming cognitive impairments (Lindblom, 1997; Dunn, 1997; Argyris, 1997). Dunn (2001: 425 -6) specifies this point where he concludes: "From the standpoint of communication theory and language, the information content of a hypothesis tends to be negatively related to its relative frequency, or probability of occurrence. Hypotheses that are mentioned more frequently – those on which there is substantial consensus – have less probative value than rarely mentioned hypotheses, because highly probable or predictable hypotheses do not challenge accepted knowledge claims." From this perspective, a transition process may be considered successful to the extent it succeeds in identifying and exploring hypotheses and options that are marginal from the perspective of dominant networks.

The ability to bring initially marginal options and hypotheses to bear is for one part dependant on the approaches and methods used in scientific analysis, which can be referred to as 'problem structuring', for another part it depends on politics. The political task in this respect is to address vested interests. Given the notion that transitions may lead to a new articulation of interests in the energy system, which is at the core of this paradigm, governing the transition would certainly not imply to exclude these interests from participation. The guiding principle for governance according to this paradigm, should however be to remove, as much as possible, the privileges that vested interests may use to resist innovations. These privileges may be found for most part in the rules, regulations and institutions maintained by government itself. We will elaborate this position with reference to two very different types of writings, first a participatory assessment 'avant la lettre' carried out by the French sociologist Touraine during the 1970s and then, the political theory of the famous 19th century British thinker, J.S. Mill.

In *La Prophétie anti-nucléire*, Touraine (1980) describes the social movements that were aroused by the decision of the French government to develop nuclear energy as the paramount generation technique ("tout électrique-tout nucléaire"). At the background of French nuclear policy, there was the hidden agenda to further develop the *surrégénerateur*, the breeder reconversion reactor technology as a means to obtain the foodstuff for nuclear bombs[18]. Touraine and colleagues organized what we would call a dialogue these days, in order to discuss the positions that social and labor movements could take with respect to the nuclear question. The major objection that came out of this dialogue against the French nuclear program was not so much the risk issue, the doubts about the

[18] The "snelle kweek reactor technology" was developed in the Netherlands by Prof. Kistenmaker. His Urenco co-operator dr. Khan stole that technology, after which he quickly became head of the Pakistan atomic energy program. His activities caused a rapid proliferation of relatively cheap nuclear technology to a.o. what are nowadays considered to be crooked states.

safety or the storage of nuclear waste. The most profound resistance related to "*la société programmée*". There was the fear that nuclear power technology would get beyond democratic control. Political power would more and more be concentrated in the hands of a few, the experts within the state. The security issue would be used as a justification against public control and participation. The *prophetical* about that struggle, to use Touraines phrasing, was that it foreshadowed a fight against a society in which the authorities could not be made accountable of their actions with respect to the security aspects of nuclear installations. Transparency and accountability would contradict the needs of security.

So, the struggle of social movements against nuclear power would, in a sense, become a struggle to defend a classical liberal conception of democracy against a technocratic paradigm of governance. The concern that comes out of the French dialogue does certainly not stand on its own. During the 1970s and 1980s, many publications warned against technocracy taking over in western democracies. This critique was not restricted to radical theorists. The well-known Yale professor Dahl (1985) published *Controlling nuclear weapons: Democracy versus guardianship*, where he analyzed the boundaries between political philosophies that argue for a concentration of power in the hands of 'experts' and democratic theories. Remarkably, also the Brundtland report (1987) mentions democracy as one of the criteria for sustainable development, thereby *de facto* taking argument with *life-boat ethics* who argue that some sort of authoritarian rule may be needed to safeguard the world from environmental disaster.

The radical and liberal rejection of a government that becomes too powerful has its roots in political philosophies, from conservatives like Hayek (1944), liberals like Rawls (1971) to anarchists like Taylor (1982). In order to complete the discussion on Governance as Challenge we will now focus on the work of J.S. Mill, not only because he is one of the most famous liberal theorists ever, but also because he combines a view on restricted government vis-à-vis individual freedom with a plea for specific interventions in the interest of future generations.

Mill's central focus, which permeates his work is that of the individual freedom versus society or the state. His point of departure is that "there is a circle around every individual human being, which no government, be it that of one, of a few, or of many, ought to be permitted to overstep" (Mill, 1957: 571). And he states with disapproval that "every increase of the functions devolving on the government is an increase of its power, both in the form of authority and still more in the indirect form of influence." (Mill, 1876: 570). There is basically no restriction on individual freedom, as long as there is no harm done to other individuals. Especially in the case of competition it is in Mill's eyes best for society as a whole, when individuals try to reach their goals and interests without having in mind the negative effects that may have for competitors. Only in case of fraud, deceit and violence the state is allowed to come to help the losers in this battlefield. Mill considers individuals the best judges of their own interest (Mill, 1876: 583) and the consumer a competent judge of the commodity (ibidem, 575). And he comes to the general conclusion as far as the role of government is concerned: "in all the more advanced communities the great majority of things are worse done by the intervention of government, than the individuals most interested in the matter would do them, or cause them to be done, if left to themselves" (ibidem, 571).

Mill lists a number of – in his eyes – unwarranted examples of state intervention. But he also admits, with some regret, that – apart from law enforcement - there are basically four legitimate reasons for government to interfere with private actions. These are (1) unequal distribution of knowledge or information, (2) concentration of power in markets, (3) *free-riding* and (4) considerations with respect to *philosophical foresight*, that is the interests of all humankind, the nation or next generations. Below, we will discuss the second and the fourth reason.

As regards the second point, Mill argues against the formation of monopolies and – at least – to take away unjustified benefits for monopolists: "I have already more than once adverted to the case of the gas and water companies, among which though perfect freedom is allowed to competition, none really takes place, and practically they are found to be even more irresponsible and unapproachable by individual complaints than the government." (Mill, 1876: 581) With respect to the question how the London water supply can best be managed, Mill states that "the case is one of those in which a practical monopoly is unavoidable. It delivers over the public to the mercy of those individuals" (Mill, 1957: 434). Hence, government may take over this task, not as a matter of principle but "of practical expediency". What is interesting here is that Mill explicitly refers to the rights of consumers and not to financial and economic reasons (lack of private profit) for government intervention. In fact, Mill suggests that consumers should be able to enact some form of control over the companies that deliver this kind of services.

As regards the fourth point Mill refers to occasions "in which the acts done by individuals, though intended solely for their own benefit, involve consequences extending indefinitely beyond them, to interests of the nation or of posteriority, for which society in its collective capacity is alone able, and alone bound, to provide" (Mill, 1957: 585). Mill mentions several examples that justify government intervention, especially if it exceeds "narrow limits of purely economic considerations."

To wrap up, Mill's writings make a case for a paradigm of governance which is based on the following considerations: (a) to restrict its own power vis-à-vis citizens and economic actors, (b) to limit the power of monopolies and other vested interests for the sake of consumer sovereignty and control, which may or may not lead to an extension of specific government tasks and (c) intervene if private actions have consequences for future generations (or any other form of externalization). Basically, Mill's liberal philosophy underlies one guiding principle, i.e. that governance must enhance competition between ideas and, therefore, take away barriers that may obstruct this. In conclusion, Governance by challenge may yield either generic or specific measures, if they are justified by this purpose and do not interfere unjustifiably with the freedom of consumers and producers to pursue their interests.

8. Conclusions and discussion

This report has given some idea of how paradigms of governance might shape the possibilities for specific technological options and trajectories. We have looked into this matter first, in Chapter 3, from the perspective of five technological options, all electric, hydrogen stationary, syngas for stationary purposes, demand management and fuel cells for the transport sector. These technologies were analyzed with respect to some institutional variables, the strategic interest security of supply, the collective or private character of the option, especially its infrastructure requirements, freedom for consumers, the degree of centralization it implies, risks for externalization of costs involved (free riding).

In Chapter 3, we found a relationship between different technological trajectories and strategies of governance to exist. With respect to the specific relationship we formulated certain hypotheses that may be further researched. We suggest that certain choices need to be made, such as a choice between infrastructures, all electric, hydrogen stationary and (syn)gas in particular. Another choice relates to balancing infrastructure requirements and the strategic relevance of security of supply. We suggest that options which may be beneficial from a security of supply position, demand management in particular, are not that much linked with vested interests with a high stake in existing or new infrastructure. We also found that the governance required is not the same for each option, given the varying complexity of infrastructure requirements. We hypothesize that the lower and less complex infrastructure requirements, the more it will be possible to govern the transition through traditional regulatory instruments or environmental agreements, possibly in combination with new instruments such as tradable emission permits.

We also hypothesize that the higher and more complex infrastructure requirements, the greater the likelihood that major government interventions will be needed. Especially in case of a breakthrough of decentralized electricity production, possibly in combination with hydrogen, society may be faced with a dual problem: On the one hand, such a development may be resisted by all (otherwise competing) vested interests in the energy system (unless these interests become redefined), on the other hand (new) infrastructure needs may come up quite suddenly. It is questionable as to whether these needs can be flexibly addressed. Experts do not consider this option very likely, but it is still relevant for our analysis. It shows after all that even if this option would become technologically feasible, cost-effective and attractive to business or consumers, it may witness major institutional barriers that require a specific type of governance.

We finally hypothesize that consumer sovereignty might remain restricted in most options, given the collective good character of large scale infrastructures. This may not have immediate implications for governance. However, if under the condition of limited choice security of supply is at stake, this may have major political and legal repercussions.

Chapter 4-7 discussed four paradigms of governance respectively. These were labeled Governance by Government, Governance by Policy Networking, Governance by Corporate Business and Governance by Challenge. For a good understanding it must be pointed out that none of these paradigms reject government intervention. Laws,

regulations, standards and even (relatively) new instruments such as environmental agreements or tradable emission permits and even specific technology support are an option in more than one paradigm, although each paradigm reveals a preference for certain instruments. Even within the paradigm Governance by Corporate Business instruments such as progressive standard setting or tradable permits are possible, as long as they do not interfere with corporate strategies.

Table 8.1 summarizes our tentative thoughts with respect to the relationship between paradigms, instrumentation and technological options. Table 8.1 should be interpreted in the Dutch context, where natural gas is important as a national sector. It is assumed that electricity will become part of international (foreign) companies. These companies may successfully resist the Dutch natural gas bias. The Netherlands may benefit from innovations (all electric) from abroad, in as far the domestic sector is involved. Instead, Governance by Government will focus on national interests for reasons related to security of supply, whereas Government by challenge will foster security of supply by innovation, which enables a combination of centralized and decentralized options. We assume that Networking focus on realizing incremental options only. We also assume that, depending on the political will to intervene with regulations as well as on technological solutions for current infrastructure problems, climate neutral transport fuels will be possible, as there is already a trend in corporate business to make a shift from oil to natural gas.

Apart from the specific implications for technology, it is the question how the paradigms of governance, which are – after all – authors' constructs derived from political theories, may relate to empirically observable governance strategies. We expect that combinations are possible, especially since policies are sector oriented, which might make it possible to link the paradigms to different sectors. We expect in practice that certain paradigms tend to exclude one another, i.e. Governance by Government versus Governance by Policy Networking and Governance by Corporate Business versus Governance by Challenge. The first distinction relates to the traditional top-down versus participation dichotomy, whereas the second distinction relates to the issue of justice, i.e. as to whether government must choose in favor of interests that are in a disadvantaged position.

Governance by Challenge may be considered a hybrid in that it articulates claims and assumptions from each of the other paradigms. It shares the notion of stakeholder participation with Policy Networking, but it stresses the demand for involving new actors in the networks. Specifically interesting is the question as to whether government might have a justification to support specific technologies. Dutch stakeholders from business have expressed a preference for 'early mover' initiatives by government (Hisschemöller and Van de Kerkhof, 2004). Traditionally, this claim has been endorsed by the paradigm Governance by Government, but, since the 1980s, this paradigm has lost a lot of credit because it led to intransparent connections between government and business. Governance by Challenge provides a new justification for government interventions, generic as well as specific. A generic policy could be to support, by alleviating taxes, climate neutral transport fuels, be it biofuels or fuel cells combined with CO2 removal and storage from natural gas. The demand for early mover initiatives with respect to specific cases of promising innovation is *inter alia* supported by the claim that surrounding countries (Germany, France) already do this, but also have a competitive

advantage because of their size. A significant difference with the kind of government support anticipated in Governance by Government is that government should not shape innovation trajectories by ex ante deciding what options might be most feasible, as is current practice. Business itself should initiate the innovation and demonstrate a willingness to invest. The preference for private business initiatives may link Challenge also to Government by Corporate Business. So it seems as if from a stakeholder perspective, Governance by Challenge may offer an alternative for incremental networking practice.

Table 8.1 A tentative view on the relationship between paradigms of governance, policy instrumentation and technological options for the Netherlands.

	Governance by Government	Governance by Policy Networking	Governance by Corporate Business	Governance by Challenge
Policy instrumentation	All instruments except environmental agreements	All instruments	All except specific technology support	All instruments
Options				
All electric	Yes Large scale	No	Yes If infrastructure need can be privately addressed	Yes Large scale and decentralized
H2 stationary	Yes Large scale, also coal or nuclear based	No Adding H2 to gas grid	No	Yes If chp can be combined with decentralized renewables and biomass
Syngas	No	Yes	Yes	No
Demand management	Yes Large scale insulation programs	Yes Only in construction / renovation	No	Yes Large scale insulation programs
Fuel cells transport	Yes By regulation and infrastructure support	?	Yes By regulation and infrastructure support	Yes By regulation and infrastructure support

In conclusion, this report offers four paradigms that may all be(come) significant under specific circumstances but may also give rise to a discussion on opportunities for political choice in an era of liberalization. If this report might carry any policy advice, it would be to take Governance as Challenge seriously as an alternative for the Policy Networking paradigm, as it may combine private initiative with an impetus of technological innovation. But also other paradigms may be seriously considered, as they may all provide a policy framework governing the transition to a sustainable energy system.

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